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SOIL POISONS for SUBTERRANEAN TERMITES

H. R. JOHNSTON

SOUTHERN FOREST EXPERIMENT STATION
PHILIP A. BRIEGLEB, DIRECTOR
Forest Service, U. S. Department of Agriculture

SUMMARY

Since 1944 the Southern Forest Experiment Station's Forest Insect Laboratory at Gulfport, Mississippi, has been carrying on intensive studies of soil poisons for use against subterranean termites.

These studies have shown that 0.8 percent gamma benzene hexachloride, [redacted] percent chlordane, or 0.5 percent dieldrin in either No. 2 fuel oil or water emulsion; 8.0 percent DDT in No. 2 fuel oil; or 10.0 percent sodium arsenite in water will give many years of protection against subterranean termites. These formulations are suggested for practical use for the treatment of soil to prevent or control infestations in buildings. The encouraging results obtained to date have prompted the establishment of tests of higher concentrations and dosages with a view to extending the period of protection.

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H. R. Johnston[2/]
Southern Forest Experiment Station

Subterranean termites are widely distributed over the tropical and temperate parts of the world, and they seem to be extending their range northward.

The key to termite control lies in construction that prevents or discourages attack. The fundamental principle is to prevent the termites from establishing or maintaining their contact between the soil, from which they obtain moisture, and the woodwork of buildings, on which they feed. This could be accomplished, to a great extent, if architects, contractors, and home builders would give more consideration to the problem.

Termites can be discouraged by removing stumps, roots, and debris from the building site and by grading to keep the site dry. Adequate clearance between the soil and woodwork, as well as proper ventilation, should be provided for buildings having crawl space. Foundations should be impervious to termites--solid concrete is preferable. Hollow block or tile foundations should be capped with four inches of reinforced concrete or provided with good termite shields. Expansion joint fillers resistant to termite penetration should be used in slab-on-ground construction. Pressure-treated wood for sills, plates, and headers may be desirable where the hazard is extreme.

No matter how carefully constructed, however, any untreated wooden building within the range of termites is vulnerable to attack. In regions where termites are abundant, poisoning the soil with chemicals is advisable to provide additional protection. The poisons are used as a supplement to good construction--not as a substitute for it.

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Chemical treatment of soil before pouring concrete slab floors is particularly valuable. Most of the cost of treating soil, either as a preventive or remedial measure, is the labor for application. Long-lasting chemicals are needed to reduce frequency of re-treating.

Soil poisons have been used in the United States for many years, but those generally recommended had various limitations. During recent years the United States Department of Agriculture has intensified the search for better poisons. Most of the research is conducted by the Southern Forest Experiment Station's Forest Insect Laboratory, at Gulfport, Mississippi. The Laboratory has extensive field installations near Gulfport, and lesser ones in other parts of the United States and in the Panama Canal Zone.

This paper describes the best formulations found to date and discusses briefly their practical application. It should be remembered that the studies are still progress and that higher concentrations and dosages are now being tested with the view of extending the period of protection. The list of formulations is therefore subject to revision.

TEST METHODS

The first tests reported herein were installed during 1944 on the Harrison Experimental Forest, about 20 miles north of Gulfport. These tests were expanded in 1946, and at the same time a series was established in the Panama Canal Zone. Many new insecticides have been added since 1946. The Mississippi tests are located in a pine-hardwood forest in a light, sandy loam soil with a clay subsoil. The Canal Zone tests are in a jungle area with a heavy soil.

Several of the most promising formulations are being tried also under practical conditions in buildings damaged by termites. These practical applications were established between 1944 and 1952. They are in North Carolina in sandy soil.

Following are brief descriptions of the 3 test methods that are being used.

Ground-board tests are intended to determine the most effective formulations and dosages for poisoning the soil prior to pouring concrete slabs. All vegetation is removed from a 17-inch square of soil, then the chemical is sprinkled evenly over the soil surface. After the chemical has soaked into the soil, an untreated sapwood pine board

measuring 1 by 6 by 6 inches is laid flat on top of the ground in the center of the treated area, so that termites must cross or penetrate the treated soil before they can attack the board.

Stake tests are designed to simulate in certain respects the application of soil poisons in trenches around the foundations of buildings. Two cubic feet of soil are removed to make a hole 15 inches in diameter and 19 inches deep. After the soil is treated with the desired dosage of chemical and replaced in the hole, a 2- by 4- by 18-inch untreated sapwood pine stake is driven to a depth of 12 inches in the center of the treated soil.

In both the ground-board and the stake tests, ten replicates of each treatment are used in a randomized block design. Treatments are considered to have failed when termites penetrate the treated soil and attack the wood. When 50 percent of the stakes or boards of a treatment are attacked, the test is closed.

Building tests are treatments of buildings that have become infested with termites. The chemicals are applied in shallow trenches along the inside and outside of concrete or brick foundations. Most buildings have two or three porches and at least one room with crawl space underneath. Each porch or room is considered as a test unit for inside treatment--i.e., treatments that are underneath the house and thus partially protected from the weather. The outside treatments are largely around basement entrances, each entrance being regarded as a test unit. When termites penetrate the treated soil and construct tubes on the foundations, the treatment is considered to have failed.

RESULTS

The field installations, being fully exposed to the weather, are more severe trials than the building tests. In general, the formulations and dosages that are effective in either the ground-board or stake tests can be relied upon to give a high degree of protection to buildings. Several formulations that gave poor results in the field tests offered good protection underneath buildings.

Main results are summarized in tables 1, 2, and 3. In evaluating these data, it was considered that only formulations giving good results for at least 5 years in one or both types of field tests in Mississippi can be safely recommended for use in the United States. The following

Table 1.--Effectiveness of soil poisons in ground-board tests in Mississippi and the Panama Canal Zone

Formulation (percentages by weight)	Location of test	Year established	Dosage per square ft.	Proportion of ground-boards undamaged by termites after exposure for									
				1 yr.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.
			Pints	- - - - - - - - Percent - - - - - - - -									
Benzene hexachloride													
In No. 2 fuel oil													
0.4 percent gamma	Miss.	1948	1/2	100	100	100	100	90	50				
	Miss.	1948	1	100	100	100	100	100	100	90	90		
0.5 percent gamma	C. Z.	1951	1	100	70	50							
	C. Z.	1951	2	90	90	60	40						
0.8 percent gamma	Miss.	1948	1	100	100	100	100	100	100	100	90		
In water emulsion													
0.4 percent gamma	Miss.	1948	1/2	100	100	80	70	70	60	60	60		
	Miss.	1948	1	100	100	100	100	100	100	80	80		
	C. Z.	1951	3	90	90	80	50						
0.8 percent gamma	Miss.	1948	1	100	100	100	100	100	100	100	100		
Chlordane													
In No. 2 fuel oil													
1.0 percent	Miss.	1948	1/2	100	100	100	100	100	100	100	100		
	Miss.	1948	1	100	100	100	100	100	100	100	100		
2.0 percent	Miss.	1948	1/2	100	100	100	100	100	100	100	100		
	Miss.	1948	1	100	100	100	100	100	100	100	100		
	C. Z.	1951	2	100	90	90	90						
In water emulsion													
2.0 percent	Miss.	1948	1/2	100	100	100	100	100	100	100	100		
	Miss.	1948	1	100	100	100	100	100	100	100	100		
	C. Z.	1951	2	100	70	50	30						
	C. Z.	1951	3	100	100	70	70						
DDT													
In No. 2 fuel oil													
5.00 percent	Miss.	1946	1/2	100	100	100	70	50					
	Miss.	1946	1	100	100	100	100	80	80	80	80	80	80
	C. Z.	1951	1	90	80	60	50						
	C. Z.	1951	2	100	90	70	50						
In water emulsion													
5.00 percent	Miss.	1951	1/2	90	60	30							
	C. Z.	1951	2	100	70	40							
Dieldrin													
In No. 2 fuel oil													
0.50 percent	C. Z.	1953	1	100	100	100							
	C. Z.	1953	2	100	100	100							
1.00 percent	C. Z.	1953	1	100	80	80							
	C. Z.	1953	2	100	90	90							
2.00 percent	C. Z.	1953	1	100	80	80							
	C. Z.	1953	2	100	70	70							
In water emulsion													
0.25 percent	Miss.	1949	1	100	100	100	100	100	100	100			
0.50 percent	Miss.	1949	1	100	100	100	100	100	100	100			
1.00 percent	Miss.	1949	1	100	100	100	100	100	100	100			
	C. Z.	1953	2	100	70	70							
	C. Z.	1953	3	100	80	80							
2.00 percent	C. Z.	1953	2	100	90	90							
	C. Z.	1953	3	100	70	70							
Sodium arsenite													
In water													
10.00 percent	Miss.	1946	1/2	100	100	100	80	40					
	Miss.	1946	1	100	100	100	85	55	55				
	C. Z.	1946	1	100	100			100	95	45			
	C. Z.	1946	2	100	100			100	100	75	35		
Controls													
Untreated	Miss.	1946	...	20									
	C. Z.	1946	...	50									

Table 2. --Effectiveness of soil poisons in stake tests in Mississippi and Panama Canal Zone

Formulation (percentages by weight)	Location of test	Year established	Dosage per 10 cu. ft. of soil	Proportion of stakes undamaged by termites after exposure for											
				1 yr.	2 yrs.	3 yrs.	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.	12 yrs.
			Gallons	Percent											
Benzene hexachloride															
In kerosene															
0.4 percent gamma	Miss.	1948	2-1/2	100	100	100	100	90	60	60	40				
0.8 percent gamma	Miss.	1946	2-1/2	100	100	100	100	100	100	100	100	90	80		
	C. Z.	1946	2-1/2	100	100			0							
In No. 2 fuel oil															
0.5 percent gamma	C. Z.	1952	5	100	100	100	100								
In water emulsion															
0.4 percent gamma	Miss.	1952	2-1/2	100	100	100	100								
	C. Z.	1952	5	100	100	90	90								
0.8 percent gamma	Miss.	1952	3-3/4	100	100	100	100								
Chlordane															
In No. 2 fuel oil															
2.0 percent	Miss.	1951	4	100	100	100	100	100							
	C. Z.	1952	7-1/2	100	100	100	100								
In water emulsion															
0.5 percent	Miss.	1952	3-3/4	100	90	90	90								
1.0 percent	Miss.	1952	3-3/4	100	100	100	100								
2.0 percent	Miss.	1951	4	100	100	100	100								
	C. Z.	1952	7-1/2	100	100	100	90								
DDT															
In No. 2 fuel oil															
4 percent	Miss.	1944	2-1/2	100	100	100	100	90	90	70	70	60	50	40	
5 percent	C. Z.	1952	5	100	100	100	100								
8 percent	Miss.	1944	2-1/2	100	100	100	100	100	90	90	90	90	90	90	70
In water emulsion															
5 percent	Miss.	1952	3-3/4	90	80	80	80								
	C. Z.	1952	5	100	90	80									
Dieldrin															
In No. 2 fuel oil															
0.5 percent	C. Z.	1953	5	100	100	100									
1.0 percent	C. Z.	1953	5	100	100	100									
2.0 percent	C. Z.	1953	5	100	100	100									
In water emulsion															
1.0 percent	Miss.	1952	3-3/4	100	100	100	100								
	C. Z.	1953	7-1/2	100	100	100									
2.0 percent	Miss.	1952	3-3/4	100	100	100	100								
	C. Z.	1953	7-1/2	100	100	100									
Sodium arsenite															
In water															
10.0 percent	Miss.	1948	3-3/4	100	100	100	100	100	100	100	100				
Trichlorobenzene															
In No. 2 fuel oil															
25.0 percent(vol.)	Miss.	1948	3-3/4	100	100	100	100	90	80	70	60				
	C. Z.	1952	5	100	100	100	80								
In water emulsion															
25.0 percent	Miss.	1948	3-3/4	100	100	100	80	80	70	60	50				
Controls															
No. 2 fuel oil	Miss.	1948	3-3/4	100	80	40									
	C. Z.	1948	5	20	0										
Untreated	Miss.	1948	...	20	10										
	C. Z.	1948	...	50	0										

Table 3. --Effectiveness of soil poisons in controlling termites in buildings during 10 years of service

Formulation	Dosage per 10 lineal ft.	Underneath buildings		Outside of buildings		Total	
		Units treated	Undamaged	Units treated	Undamaged	Units treated	Undamaged
	Gallons	Number	Percent	Number	Percent	Number	Percent
Coal-tar creosote							
In No. 2 fuel oil							
50.0 percent	2	19	95	8	63	27	85
Chlorinated toluene (2-chloro-6-nitro-toluene)							
In No. 2 fuel oil							
25.0 percent	2	23	100	8	50	31	87
DDT							
In No. 2 fuel oil							
5.0 percent	4	59	97	28	75	87	90
10.0 percent	4	22	100	7	57	29	90
In water emulsion							
5.0 percent	4	39	97	4	50	43	93
Orthodichlorobenzene							
In No. 2 fuel oil							
25.0 percent	2	86	92	19	42	105	83
	4	6	100	2	50	8	75
Pentachlorophenol							
In No. 2 fuel oil							
5.0 percent	4	17	94	3	33	20	75
Sodium arsenite							
In water							
10 percent	2	39	100	0	...	39	100

formulations are among the best tested thus far, and are suggested for practical use to protect buildings:

1. Benzene hexachloride, 0.8 percent gamma in No. 2 fuel oil or water emulsion.
2. Chlordane, 1.0 percent in No. 2 fuel oil or water emulsion.
3. Dieldrin, 0.5 percent in No. 2 fuel oil or water emulsion.
4. DDT, 8.0 percent in No. 2 fuel oil.
5. Trichlorobenzene, 25.0 percent (by volume) in No. 2 fuel oil.
6. Sodium arsenite, 10.0 percent in water.

A dosage of 1 to 1-1/2 gallons of any of the emulsions or of the water solution of sodium arsenite per ten square feet of surface area is recommended for over-all treatment before pouring concrete slabs. Four gallons per ten cubic feet of soil should be used for treating around foundations.

These concentrations and dosages provide a good margin of safety, so that a long period of protection can be expected. Since the cost of the

chemical usually is only a small portion of the total cost of treating a building, it appears logical to use enough chemical to prevent attack for as long as possible.

Tables 1 and 2 show that much heavier dosages and concentrations are necessary in the Canal Zone than in Mississippi. For example, 2 percent chlordane in water emulsion at a dosage of one pint per square foot in ground-board tests in Mississippi is still 100-percent effective after seven years; in the Canal Zone, a dosage of two pints per square foot was only 30-percent effective for four years.

Chemicals that gave 50-percent or less protection for five years (when tested at practical concentrations and rates of application) are considered inferior to those suggested for use. These include acetylene tetrachloride, chlorinated nitrotoluene, copper ammonium fluoride, copper naphthenate, copper sulphate, coal-tar creosote, coal-tar creosote plus orthodichlorobenzene, hexachloroethane, lead arsenate, methoxychlor, monochloronaphthalene, orthodichlorobenzene, pentachlorophenol, sodium dinitroorthocreosolate, and zanthane.

PRACTICAL APPLICATION OF SOIL POISONS

As supplements to good construction, soil poisons are practical and effective in preventing attacks on buildings. They are also valuable in stopping existing infestations. Since there are many variations in construction, a detailed discussion of preventive and remedial treatments is impossible. The essential thing is to apply the insecticide in such a way that it forms a barrier to termite entry.

Preventive measures.--Slab-on-ground construction is very susceptible to termite attack, and remedial measures are difficult and expensive. Therefore, prevention is highly desirable. Protection can be secured for many years by poisoning the soil, before the slab is poured, with any one of the previously listed emulsions or with a water solution of sodium arsenite.

Treatment should be made after all filling and grading is complete. Critical areas, such as along foundation walls and around plumbing, should be treated by the trenching method described later under remedial measures. In addition, an over-all surface treatment at a dosage of not less than one gallon per ten square feet is recommended if the fill is soil or unwashed gravel. If cinders, washed gravel, or similar coarse material is used in the fill, the dosage should be increased by at least one-half.

Voids in hollow-block foundations should be treated with at least two gallons per ten linear feet of wall. For buildings having crawl space or basements, the trench and void treatments can be used as preventive measures without an over-all surface application.

Remedial measures.--In remedial treatment, slab-on-ground construction presents the most serious problems, because it is difficult to get the poisons where they will be effective. One method of treating is to drill holes through the concrete slab at any point where termites may enter. The holes should be spaced about a foot apart to insure proper treatment of the soil underneath. Another method is to drill through the foundation walls from the outside and force the chemical just underneath the slab along the inside of the foundation and along expansion joints. Any one of the formulations listed above should be applied at the rate of four gallons per ten linear feet of foundation or expansion joint.

To treat buildings having crawl space or basements, dig a trench adjacent to and around all piers and pipes and along the sides of foundation walls. A trench six to eight inches deep and about the same width is ample for solid concrete foundations that have not developed cracks. While the trench is open, one of the previously mentioned formulations should be poured in at a rate of two gallons per ten linear feet of trench. Then, as the excavated soil is put back into the trench, it also should be treated at the rate of two gallons per ten linear feet. This rate of application is equal to about four gallons per ten cubic feet of soil, assuming that the chemical spreads downward and outward from the trench. For brick, hollow block, and concrete foundations that have cracked, care should be taken to dig the trench to the footing. This is a precaution to prevent termites from gaining hidden entry through voids in these types of foundations. The amount of chemical applied in deep trenches should be increased correspondingly. Voids in hollow-block foundations should be treated as described under preventive measures.

WARNING! All of these chemicals are poisonous if taken internally, and some of them can be absorbed through the skin. If they are spilled on the body, they should be washed off immediately with warm, soapy water. Sodium arsenite is very toxic to plants and should not be used where the roots of valuable plants will contact it. The oil solutions will damage plants if applied to their roots.